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Applied research on Enchytraeidae in Central Amazonia: project approach, methodology and first results

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Abstract

Enchytraeidae are known to be an important group of soil animals in temperate regions of the world, but their contribution to ecosystematic soil functions, especially litter decomposition, in the humid tropics remains largely unexplored. Therefore, as part of the SHIFT project ENV 52 »Soil Fauna and Litter Decomposition« the species composition, abundance and biomass of these organisms have been determined in a polyculture forestry plantation and in plots of nearby secondary and primary forest in central Amazonia since 1997. The aim of the project is to study the regeneration and better use of already degraded areas in order to diminish the human impact on primary rain forests in Amazonia. The basic hypothesis of all investigations within this project is that soil fauna (e.g. enchytraeids) and micro-organisms are extremely important for the maintenance of »healthy« (functional) nutrient cycles at these plots. In this contribution three aspects of this – still running – project we present:

- a brief overview on the basic hypothesis and organisation of the SHIFT project ENV52;
- the adaptation of methods known from temperate regions to the study of enchytraeids in a neotropical rain forest;
- first results gained in the project on enchytraeid abundance and species spectrum.

Introduction

Considerable areas of the rain forests of Amazonia (Brazil) are characterized by nutrient poor soils, which make sustainable agri- and silviculture difficult. In order to develop an ecologically, socially and economically viable system of agriculture adapted to the conditions of Amazonia, several projects are currently being carried out at the Brazilian Agroforestry Research Facility EMBRAPA-CPAA (Empresa Brasileira de Pesquisa Agropecuária, Centro de Pesquisa Agroflorestal na Amazônia Ocidental) in Manaus (Amazonas State, Brazil) within the German-Brazilian Scientific Cooperation Program »Studies on Human Impact on Floodplains and Forests in the Tropics« (SHIFT) (projects ENV 23, 42, 45). The principal aim of these projects is to develop methods for

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sustainable land use in Amazonian rain forests, using an experiment on recultivation of a fallow rubber plantation with mixed plantations of annual and perennial plants (polyculture systems). In our project ENV 52, entitled »Soil Fauna and Litter Decomposition«, litter quantity and quality, decomposition rates, and the abundance, biomass, and respiration of soil-inhabiting microbes, arthropods (especially collembolans, mites, ants, spiders and termites) and earthworms are studied comparatively in a forestry polyculture consisting of 4 tree species and in plots of nearby secondary and primary forest (BECK et al. 1998). In intact forests the soil fauna and microorganisms are abundant and extremely diverse, building a complex network of interacting processes. In secondary forests and plantations abundance and diversity of soil organisms may be altered, which possibly interferes with the nutrient cycling (SWIFT et al. 1979).

The aim of this study is to evaluate the specific contribution of the different functional soil fauna groups and of the soil microflora to the decomposition of organic matter and the resulting nutrient supply to the plants. Our basic hypothesis is that a functional soil fauna is of extreme importance for the maintenance of »healthy« nutrient cycles in the systems, and that biotic and abiotic factors of the sites can be managed in order to optimize the cycling of nutrients. In view of the high variability in the distribution of the fauna in tropical soils, only an extensive and very time-consuming sampling scheme will allow to address these questions and to provide a model of the underlying processes which will be applicable to similar situations.

Since the project ENV52 is still running (sampling started in July 1997 and will be continued at least until early summer 1999), this contribution focuses mainly on one soil fauna group (Enchytraeidae), methodological considerations and preliminary results. Any conclusions have to be confirmed by future collections.

Material and Methods

Site Description

The study area is located at km 29 on the road Manaus-Itacoatiara close to the agroflorestal research station EMBRAPA-CPAA (Empresa Brasileira de Pesquisa Agropecuária, Centro de Pesquisa Agroflorestal na Amazônia Ocidental) in the state of Amazonas (Brazil). The investigations are taking place on an abandoned plantation of rubber trees (Seringueira) which has been used since 1992 as a polyculture forestry research area divided into 90 experimental plots of 32 x 48 m each. All samplings of the project ENV52 are being performed simultaneously on three plots (Fig. 1):

- the polyculture system (POA/POC), a silvicultural plantation of four different tree species (*Hevea* spp. (Euphorbiaccae), *Schizolobium amazonicum* (Caesalpiniaceae), *Swietenia macrophylla* (Meliaceae) and *Carapa guianensis* (Meliaccae), planted in 1992, with secondary vegetation admitted between the tree rows;
- a secondary forest (SEC), growing since 1984 immediately nearby the experimental plantation; it is dominated by various *Vismia* sp. species;
- a primary forest (terra firme; FLO) adjacent to the experimental plantation.

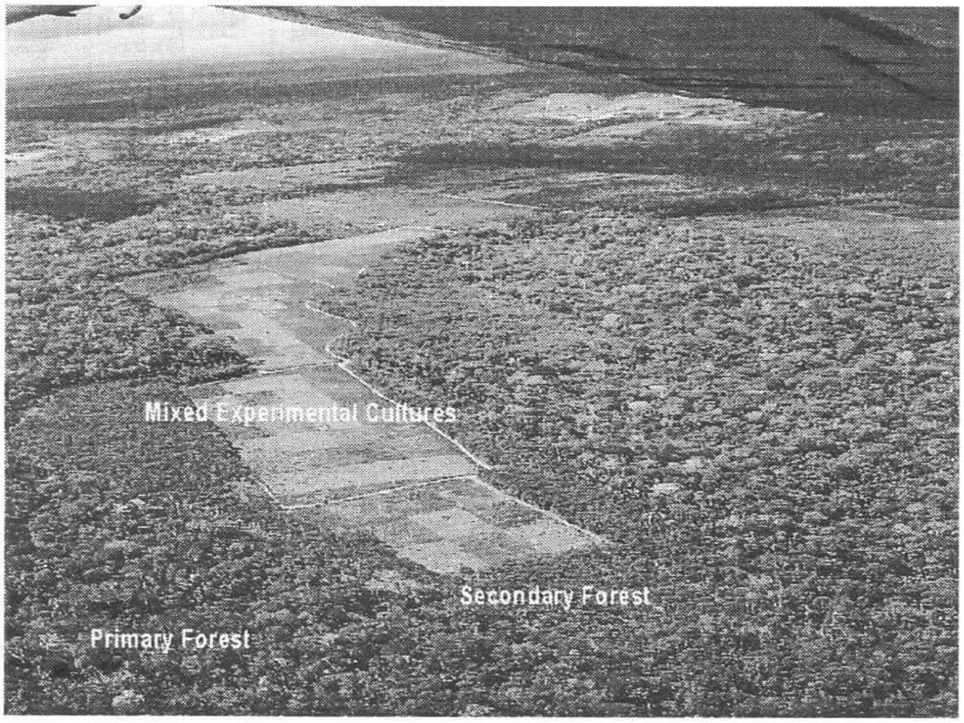

Fig. 1: Aerial view of the study area

According to FAO, the soil is an acid clay (Ferrasol). Its properties are practically the same at all plots, but the vegetation cover differs greatly due to broad open spaces at POA/POC (Table 1). Long-term measuring devices were exposed in the study sites (litter-sampler, temperature and humidity-loggers) in order to study litter input and climatic parameters. In 1997, the mean annual air temperature was 27.9 °C (maximum 56 °C in POA) and soil temperatures usually range between 21.5 and 23.8 °C. The annual precipitation was 2585 mm. Compared with the long-term means, 1997 was an untypical, extraordinarily dry year in the whole region of central Amazonia, which might have been an effect related to the El Niño phenomenon.

Sampling and extraction methods

Enchytraeidae are sampled quarterly within the standard sampling program of the main project using a soil corer (diameter: 6.4 cm). In the field samples are differentiated into two depths (litter-layer including the root-map, and mineral soil 0–5 cm). In total, 120 samples are taken per date: POA and POC 10 samples each; SEC and FLO 20 samples each; differentiated into 2 depths. In the laboratory the Enchytraeidae are collected from litter or soil by the wet-extraction-method developed by GRAEFE and subsequently identified in vivo using a microscope (RÖMBKE 1995).

Since up to now nearly no ecological studies on Enchytraeidae have been performed in the tropics, some methodological details will be given here. In general, sampling and

Table 1: Short characterization of the soil properties of the three study plots

Parameter	*FLO*	*SEC*	*POA/C*
Vegetation	Primary forest	Secondary forest e.g. *Vismia* sp.	Polyculture e.g. rubber
Soil Type	Sandy clay (60 % clay, 25 % sand, 15 % silt)		
pH value (H_2O)	4.2–4.8	4.7–5.0	4.2–6.0
Org. content %	?	2.4–5.3	2.4–6.8

extraction is quite similar in comparison to ecological studies in temperate regions. In case a laboratory (including air condition) is provided within a short distance from the study site nearly no differences occur. But even if such a laboratory is not at hand, the investigation of enchytraeids is possible. In such a case, a very quick transfer of the cooled samples to a laboratory must be done. For example, in this project cooled samples were sent to Germany twice, but since such a transport takes only four to six days a normal treatment (extraction and species determination) was possible. In the circumstance of this contribution, cooling means to secure a range of 15–25 °C. It could be shown that enchytraeids from the EMBRAPA site where the soil temperature fluctuates usually between 21.5 and 29.9 °C (MARTIUS, pers. comm.) are very sensitive against temperatures below approximately 10 °C.

Usually, a soil corer (the diameter should be between approximately 5 and 7 cm), a plastic-hammer (especially in the dry season), a knife, labelled plastic bags (1 L) and a cooling container is all what is needed in the field. Due to the extreme climatic conditions an intensive and well organised preparation (e.g. pre-labelling) is necessary to minimize the time between taking the samples and storing them in the cooling device. The samples should be stored not longer than 2 weeks in the cooling device.

In any case the wet extraction method should be used, but for tropical samples a room temperature of approximately 20–22 °C is optimal. The extraction should be started as soon as possible. As a first step the fresh weight of all litter samples should be determined. Afterwards, the samples are filled into sieves which are placed into bowls containing water. The samples in the sieves should be submerged completely, but the bottom of the sieves should not reach the bottom of the bowls. To ensure a recovery of Enchytraeidae from the samples of more than 90%, the extraction time of soil should be 3 and of litter 3–5 (up to 8 days depending on the amount of the sample) days at 22 ± 3 °C. These times can be modified if, e.g. in the dry season, the overall number of individuals in a sample is close to zero. At the end of the extraction time a small amount of water together with the suspended soil is transferred to a petri dish. Within a few minutes up to one hour the suspended particles will have settled down and the water will be clear. The Enchytraeidae can now be collected out of the petri dish under a binocular using a softsteel forceps. The microscopic identification should be done as soon as possible (within hours), because the animals die relatively quickly in water. If the worms move too fast on the slide, they can be anaesthetised with CO_2 (use a drop of mineral water); but use it with care, otherwise the study objects will be killed). Enchytraeidae can be

Table. 2: Numbers of Enchytraeidae (ind/m^2 x 1000 in the litter and soil layer and in total) from the three study areas and at different sampling dates

	FLO			*SEC*			*POA/C*		
Date:	Litter	Soil	Total	Litter	Soil	Total	Litter	Soil	Total
07/97	1.5	4.0	5.5	1.6	5.4	7.0	1.0	2.2	3.2
09/97	1.0	1.5	2.5	1.1	1.6	2.7	1.0	1.7	2.7
12/97	0.5	1.1	1.6	0.6	1.1	1.7	0.7	1.3	2.0
03/98	2.5	1.0	3.5	2.0	1.2	3.2	1.9	3.2	5.1
06/98	6.1	2.5	8.6	6.1	3.2	9.3	1.6	6.4	8.0
09/98	4.0	1.8	5.8	2.4	1.5	3.9	0.6	1.5	2.1

preserved for further studies (e.g. species descriptions) in 70% ethanol, however the preservation is accompanied by a loss of visible morphological details. Selected animals can be coloured and mounted individually on object slides. However, this procedure is very time-consuming and no detailed description is available in the literature (BEYLICH, pers. comm.).

Results

After six sampling dates in the period from July 1997 to September 1998, the following preliminary results can be presented: The number of species appears to be relatively high (approx. 20). Most of the species belong to the mainly neotropical genera *Guaranidrilus* (5) and *Hemienchytraeus* (5). Species of genera known from the Northern Hemisphere like *Achaeta* sp. (4) and *Enchytraeus* sp. (2) were also found. At least one species could not be assigned an established genus so far. With one (or two ?) exceptions, none of the species found at the site have been described scientifically. The oligochaete fauna seems to be relatively diverse in comparison to soils of temperate regions. Unfortunately, no data from tropical sites are available in such detail (some Indian studies have not been checked so far). It should be mentioned that at least five species of other microdrile oligochaete families (mainly Naididae and Tubificidae) can be found in the three study plots.

The abundance of enchytraeids in the three plots (on average 3.900–4.600 ind./m^2) is low in comparison to many temperate regions but higher than the (very few) numbers reported from other tropical rain forest sites (approx. 1.000 ind./m^2; e.g. PETERSEN & LUXTON 1982). Average values, corrected for a square meter and differentiated according to the two layers (litter and soil) are given in Table 2. Very often the litter layer is less inhabited than the soil layer but this ratio~~n~~ can change at certain dates (Fig. 2). It seems that the number of enchytraeids is highest after the rainy season (June/July) and decreases in between, reaching a minimum in December. The three areas can also be distinguished by their species composition and the dominance spectrum, respectively. However, due to the complex climatic situation in 1997 and the relatively few data gained so far it is too early for a final assessment.

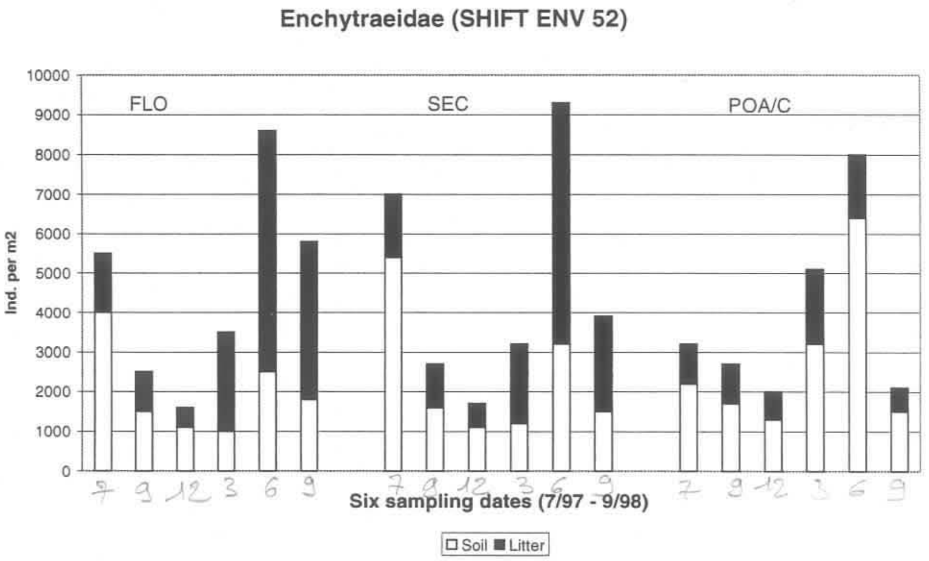

Fig. 2: Abundance (ind./m^2) of enchytraeids at the three study plots at the six sampling dates

Discussion

Up to now, there is no standard set of methods for soil ecological investigations in tropical rain forests. The only text coming next to such a standard is the well-known »Handbook of Methods of Tropical Soil Biology and Fertility« (ANDERSON & INGRAM 1993). This book focuses mainly on soil fertility and gives very detailed descriptions of soil chemical and physical methods. Unfortunately, the handbook is far less complete in the field of soil biology: For example, enchytraeids are not mentioned at all. Even the most comprehensive manual for the study of soil biology is only available in German and covers mainly temperate regions (DUNGER & FIEDLER 1997). Therefore, the first outcome of the project ENV52 is a compilation of soil biological methods for the use in tropical rain forests. The established sampling methods together with work plans and detailed step-by-step instructions for many procedures have been compiled into a »handbook«, accessible via internet from our homepage (since March 1998): http://www.cenargen.embrapa.br/~mgarcia/shift.

Summarising our findings hitherto, the enchytraeid biocoenosis is more important as regards abundance and species diversity than was previously known from tropical rain forests. However, more data are needed to evaluate their functional role in the soil of the different plots, especially in comparison to other soil organisms. Studies on respiration biology and feeding activity are currently under way to answer this question.

The application of the results of this study to other, similar areas, and the transfer of the conclusions for practical purposes (improvement of sustainability of land use techniques in the humid tropics) is supposed to be facilitated by the comprehensive evaluation of the data in co-operation with other SHIFT projects jointly studying the EMBRAPA site at the end of the investigations.

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